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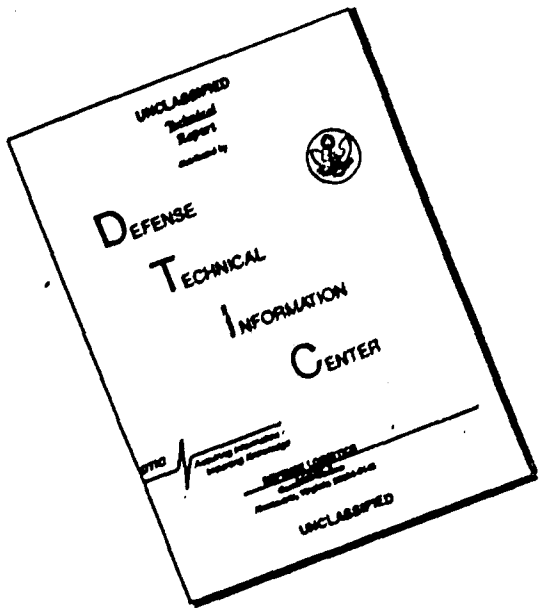

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U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

REPORT NO. 728

DEFORMABLE PROJECTILES (SQUEEZEBORE)

20th Partial Report

RECOVERY FIRING OF 5"/3"75 DEFORMABLE PROJECTILES WITH FORWARD SKIRTS

FINAL Report

Copy No. 19

Task Assignment NPG-13-Re3b-215-2

Classification CONFIDENTIAL

Recovery Firing of 5"/3"75 Deformable
Projectiles with Forward Skirts

- -

PART A

SYNOPSIS

1. Ten (10) 5"/3"75 deformable projectile bodies and forward skirts were manufactured. These bodies and forward skirts were assembled with rear flanges and dummy nose plugs, and fired for recovery from the 5"/54 gun with and without the muzzle squeeze attachment, to determine projectile performance.

2. The design of forward skirt tested did not perform satisfactorily. The skirt functioned properly in the gun, but as the projectile left the muzzle the skirt expanded, at times to its original diameter, due to gas pressure.

Recovery Firing of 5"/3"75 Deformable Projectiles with Forward Skirts

- -

TABLE OF CONTENTS

Recovery Firing of 5"/3"75 Deformable Projectiles with Forward Skirts

- -

PART B

INTRODUCTION

1. AUTHORITY:

This test was authorized by references (a) and (b).

2. REFERENCES:

a. BUORD ltr Re3b-PTL:mf Ser 6150 of 20 Feb 1950.
b. TelCon P. T. Lanham (Re3b BUORD) and R. B. Butler (NAVPROV) on 20 Jul 1950.
c. BUORD Sk. 147681 Forward Skirt and Body Details for 5"/3"75 Deformable Projectile.
d. BUORD Sk. 238752 Assembly and Details (Rear Flange Pc 6A ACME thread) of 5"/3"75 Deformable Test Slug.
e. BUORD Sk. 147423 Details and Assembly 5"/3"75 Deformable Projectile Type Ex 24.

3. BACKGROUND:

The Bureau of Ordnance requested, in reference (a), manufacture and recovery firing of ten (10) 5"/3"75 deformable projectiles with forward skirts in place of the three forward studs. In reference (b) permission was granted to fire two rounds with four (4) equally spaced vent holes in the forward skirt.

4. OBJECT OF TEST:

The object of this test was to determine the serviceability of deformable projectiles with a particular design of forward skirt.

5. PERIOD OF TEST:

a.	Date of Letter Authorizing Project	20 Feb 1950
b.	Date Program Activities	1 Jun 1950
c.	Date Last Test Conducted Prior to This Report	10 Aug 1950

Recovery Firing of 5"/3".75 Deformable Projectiles with Forward Skirts

PART C

DETAILS OF TEST

6. DESCRIPTION OF ITEM UNDER TEST:

The projectile bodies and forward skirts were manufactured in accordance with Figure 26, Appendix (B). The rear flange was in accordance with reference (d), and the nose plug was manufactured in accordance with Figure 28, Appendix (B). The vent holes in the forward skirt were in accordance with Figure 25, Appendix (B). A view of the assembled projectile is shown in Figure 1, Appendix (B).

The forward skirts were made of mild steel (AISI 1020 normalized).

The physical properties called for in reference (e) for the projectile body could not be met with the steel on hand. Appendix (E) describes the steel, method of heat treatment, chemical analysis, and physical properties, of the material used in manufacture of the bodies.

7. PROCEDURE:

Ten (10) projectiles were prepared for recovery firing at service charge. Three (3) were fired in the 5"/3".75 Gun Type A Mod 0 without the muzzle squeeze attachment and seven (7) were fired in the same gun with the vented squeezer. The three projectiles fired without squeezer were fired empty, and the seven fired with squeezer were loaded with Epsom salt. Projectiles of similar design when fired at high velocity into the recovery bin had been breaking up. It was believed that if the projectiles were salt-loaded they would withstand the impact better.

Measurements were taken of the diameter at various points of the body, rear flange and forward skirt, after firing, to show the diameter after passing through squeezer with a diameter of 3".765. Each assembled part was stenciled with a Naval Proving Ground number to facilitate identification.

Recovery Firing of 5"/3"75 Deformable
Projectiles with Forward Skirts

- -

Velocity, copper crusher gage pressures and spin rates (Appendix (D)) were taken. Star gauge data and transverse strain gauge readings on the muzzle squeeze attachment were taken and the results are given in Appendix (C) and in Figure 27, Appendix (B). Fourteen (14) rounds were fired through this squeezer prior to this test.

Microflash photographs were taken of the projectiles in flight 150 feet from the muzzle and are included in Appendix (B), (Figures 14 to 23 inclusive). Photographs of the recovered projectiles are also included in Appendix (B), (Figures 2 to 10 inclusive). The five recovered projectiles that were fired through the squeezer were sectioned along the center line and photographed (Appendix (B), Figures 11 to 13 inclusive) to show the conditions of the forward skirt and rear flange.

8. RESULTS AND DISCUSSION:

Complete before and after firing data are given in Table I, Appendix (A). The results of this test indicate that a forward skirt of this design is not satisfactory in that gas pressure causes expansion of the skirt as it leaves the muzzle. The projectiles with vent holes in the skirt did not show improved performance.

There was no evidence to indicate unsatisfactory performance of the projectile bodies, but in two cases the rear flange was observed to fail. One projectile (Appendix (B), Figure 3) fired without muzzle squeezer broke at the rear flange thread. This occurred after it had entered the recovery bin, since the microflash picture (Appendix (B), Figure 15) and the yaw cards did not show any sign of breakage. One projectile (Appendix (B), Figure 5) fired with muzzle squeezer broke into three pieces. Three round holes approximately 3-3/4 to 4-1/4 inches in diameter were in each yaw card, and the microflash picture caught a part of the rear flange (Appendix (B), Figure 17). This piece and the nose plug were recovered, but the body was not recovered and the cause of the failure was not determined.

The device of salt-loading the projectile bodies improved the recovery procedure by definitely reducing the tendency of the bodies to break up in the bin.

PART D

CONCLUSIONS

9. It is concluded that design of forward skirt tested did not perform satisfactorily. The skirt functioned properly in the gun, but as the projectile left the muzzle the skirt expanded, at times to its original diameter, due to gas pressure.

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Captain, USN
Ordnance Officer
By direction

CONFIDENTIAL NPG REPORT NO. 723

U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

Twentieth Partial Report

on

Deformable Projectiles (Squeezebore)

- -

Final Report

on

Recovery Firing of 5"/38.75 Deformable

Projectiles with Forward Skirts

Project No.: NPG-13-Re3b-215-2
Copy No.: 19
No. of Pages: 6

Date:

FEB 13 1951

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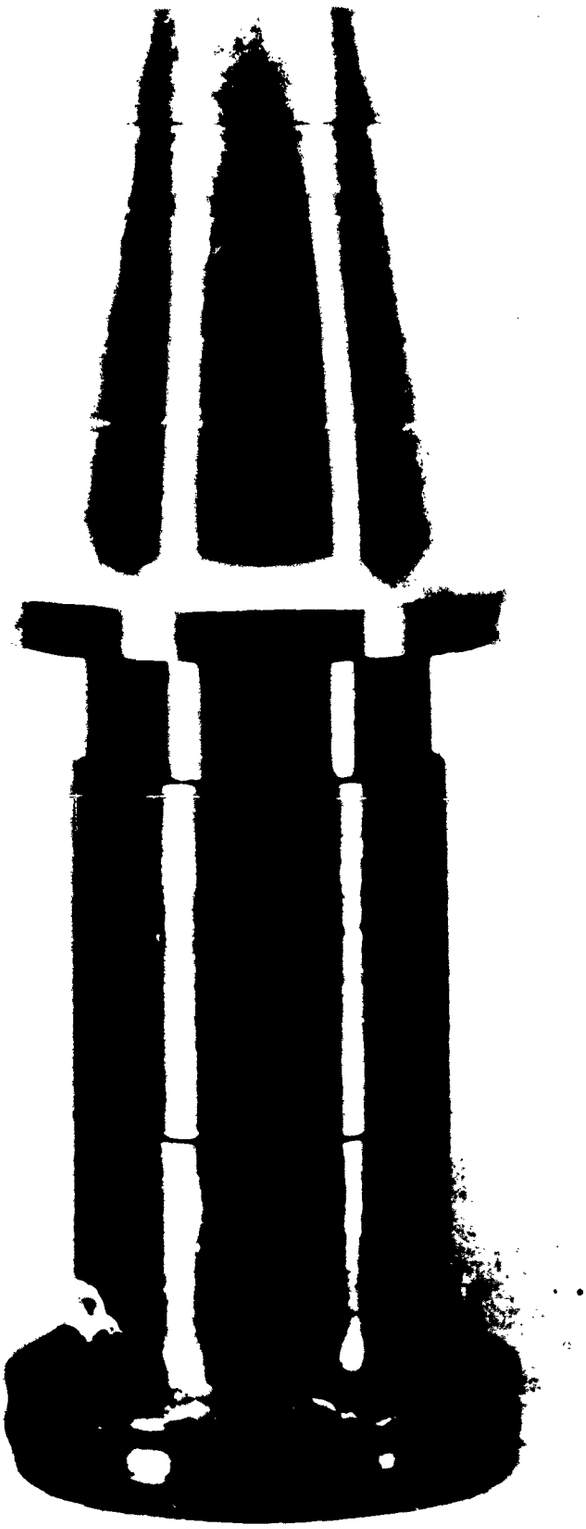
TABLE I (Continued)

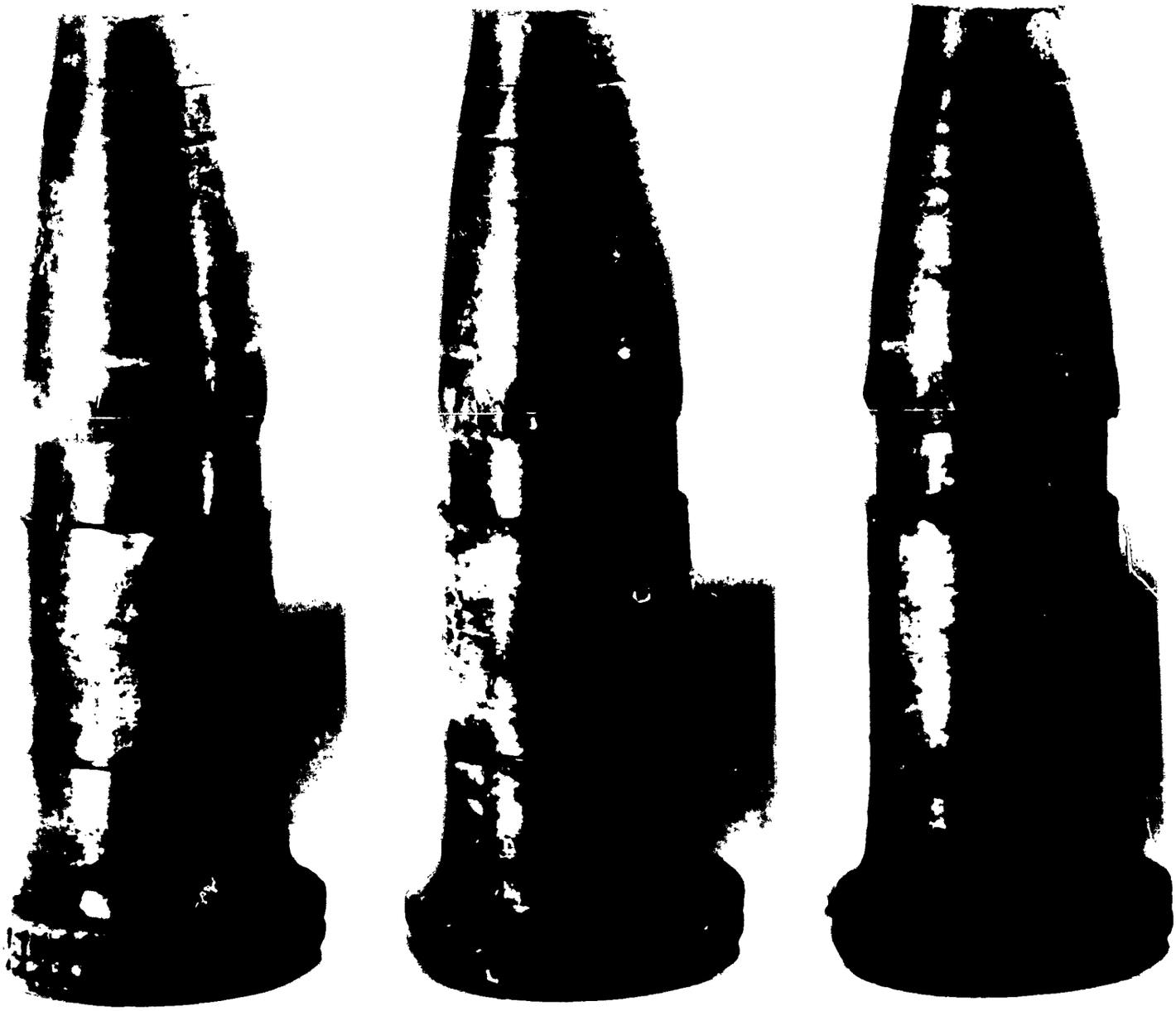
Proj. No.	Condition	Pdr. Chg. (Lbs.)	Pressure (t.s.i.) Ea. Gage	Pressure (t.s.i.) Ave.	Muzzle Velocity (ft/sec)	% Nominal Spin	Diameters after Firing: Rear Flange Aft.	Rear Flange Fwd.	Body Rear	Body Fwd.	Fwd. Skirt (a)	Weight Lbs.: Body	Fwd. Flange	Rear Flange	Nose Plug	Salt	Total
434 (c)	C	18.5	18.8 18.5 17.8	18.4	3883							15.52	2.31	7.15	3.24	1.65	29.87
435	C	18.5	19.4 19.5 19.2	19.4	3899	106.5	Damaged	3.777	3.750	3.745	3.760	15.54	2.30	7.19	3.23	1.66	29.92
436	B	18.5	19.1 19.3 19.7	19.4	3890	109.0	3.800	3.782	3.752	3.743	3.750	15.55	2.30	7.13	3.24	1.65	29.87
437	B	18.5	19.1 19.4 20.1	19.5	3883	103.3	Damaged	3.779	3.751	3.743	3.800	15.55	2.29	7.21	3.25	1.63	29.93

A. Fired in 5"/3875 Gun Type A Mod. 0, without muzzle squeeze attachment. Gun had 83.3 MSR prior to test.
B. Fired in 5"/3875 Gun Type A Mod. 0, with muzzle squeeze attachment. Squeeze had 14 rounds fired through it prior to test.
C. Forward Skirt had 4-3/8" dia. vent holes and fired in gun with squeezer.

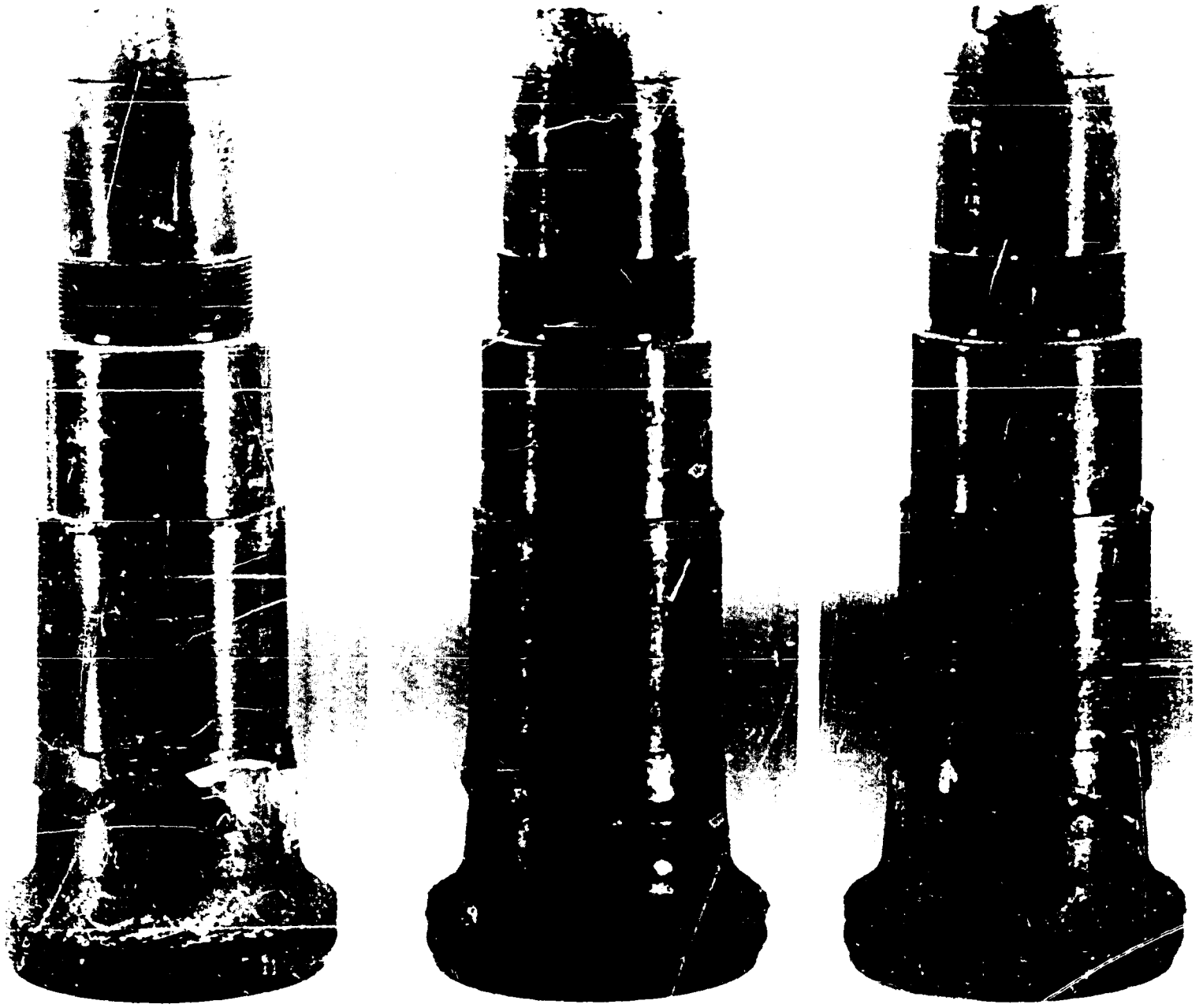
(a) Diameter taken at datum dia. (Before firing 3.659)
(b) Projectile No. 431 broke in three pieces in gun or soon after it left muzzle, made three holes in yaw cards.
(c) Projectile No. 434 had good flight, no yaw; but went completely through recovery bin and was not recovered.



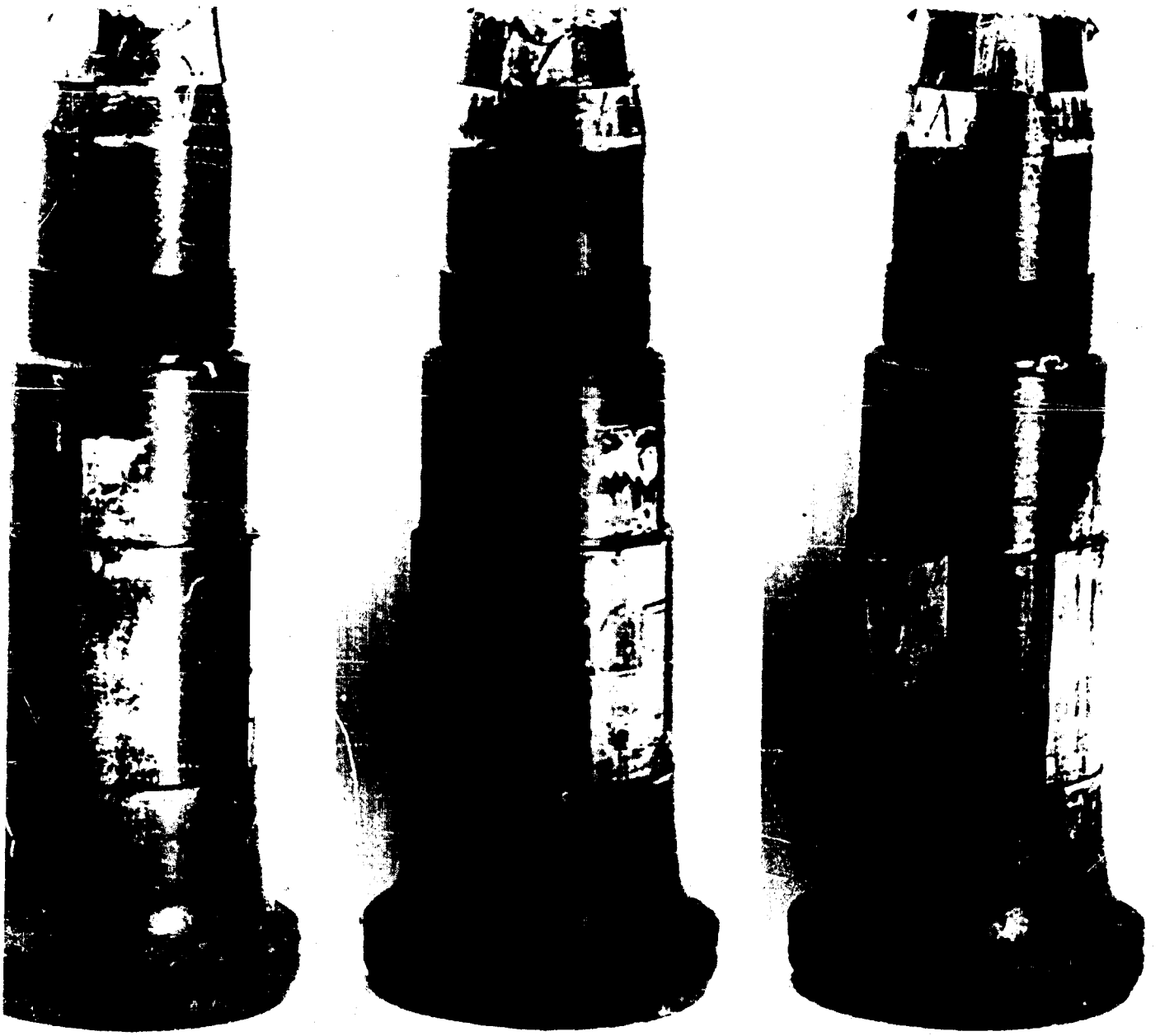
NP9 42198 - 5"/38 Deformable Projectile, with Forward Skirt, before firing.
18 May 1950 Figure 1 CONFIDENTIAL



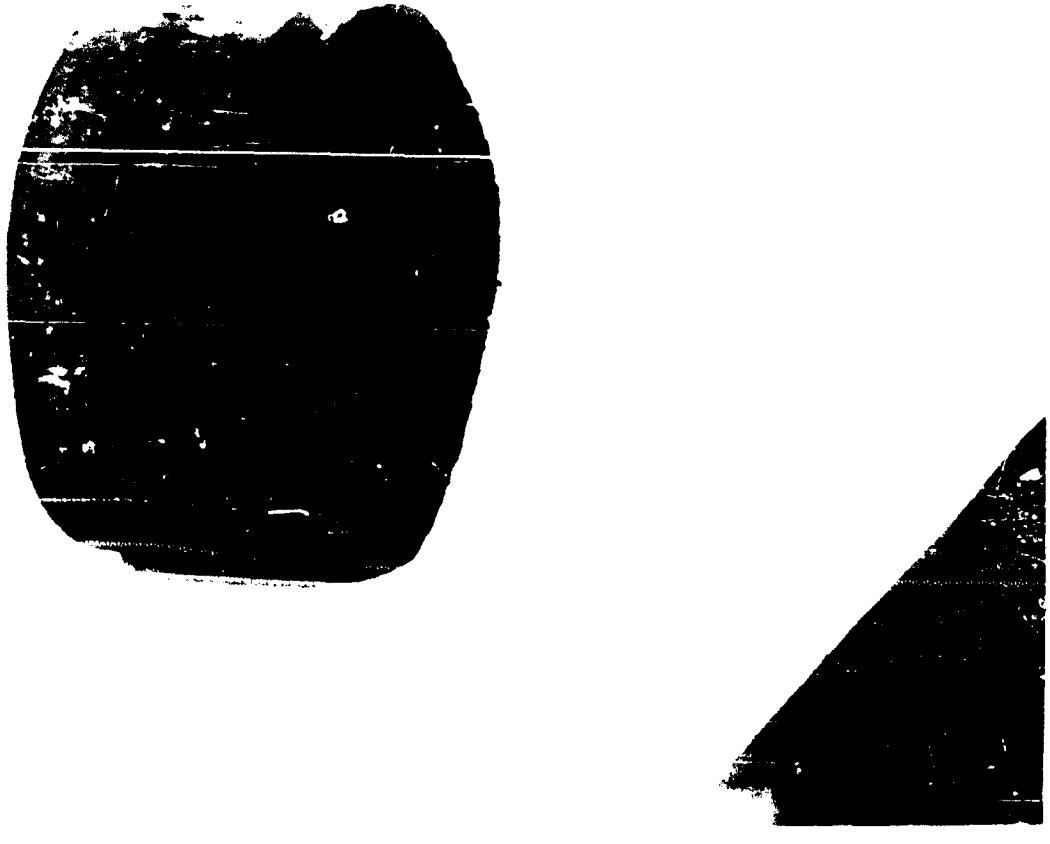
NP9 42199 - Three views (120° apart) of recovered 5"/3.75
Deformable Projectile No. 428. Fired without muzzle squeezer.
1 June 1950 Figure 2 CONFIDENTIAL



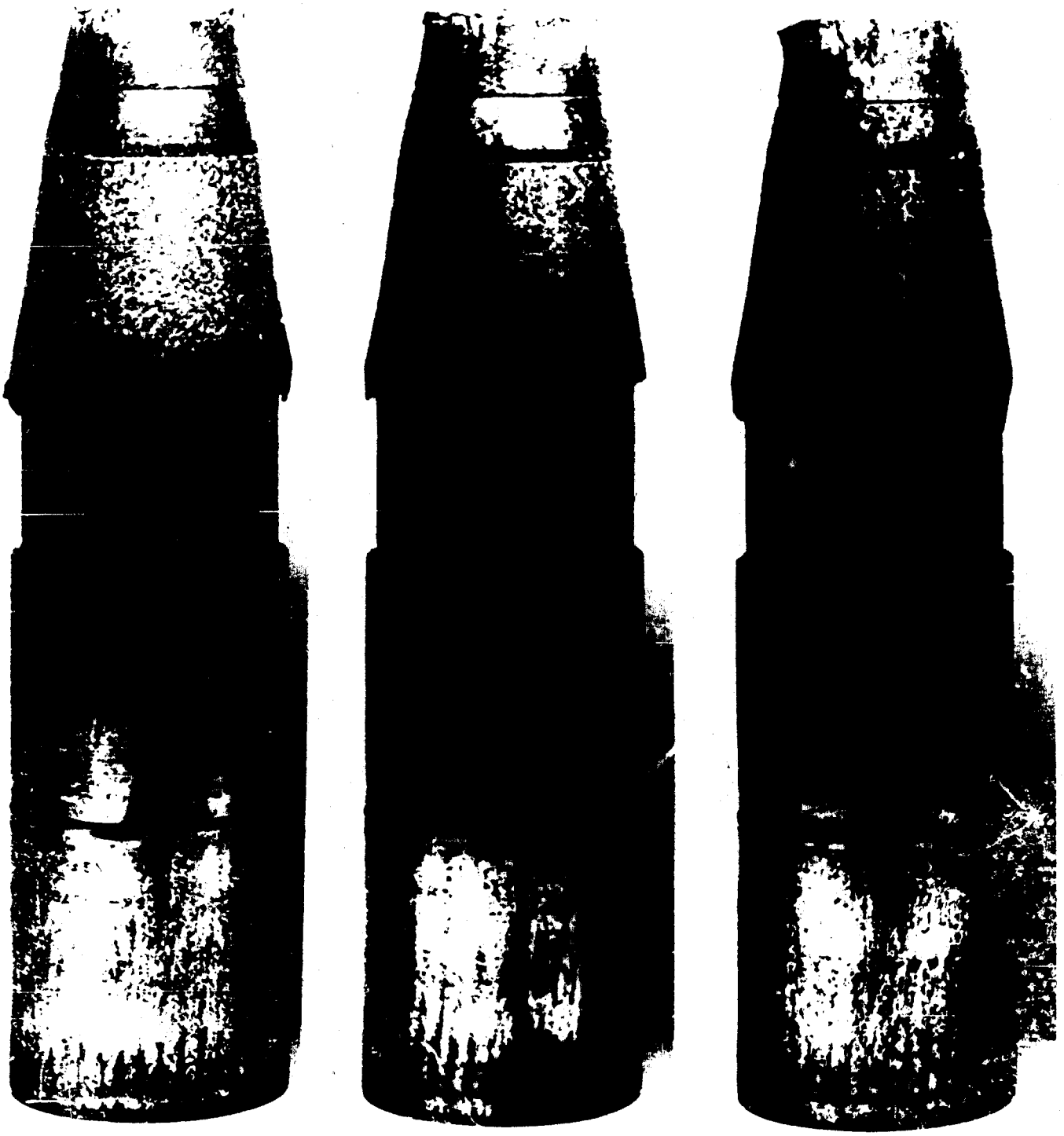
NPG 42200 - Three views (120° apart) of recovered 5"/3"75 Deformable Projectile No. 429. Fired without muzzle squeezer.
1 June 1950 Figure 3 CONFIDENTIAL



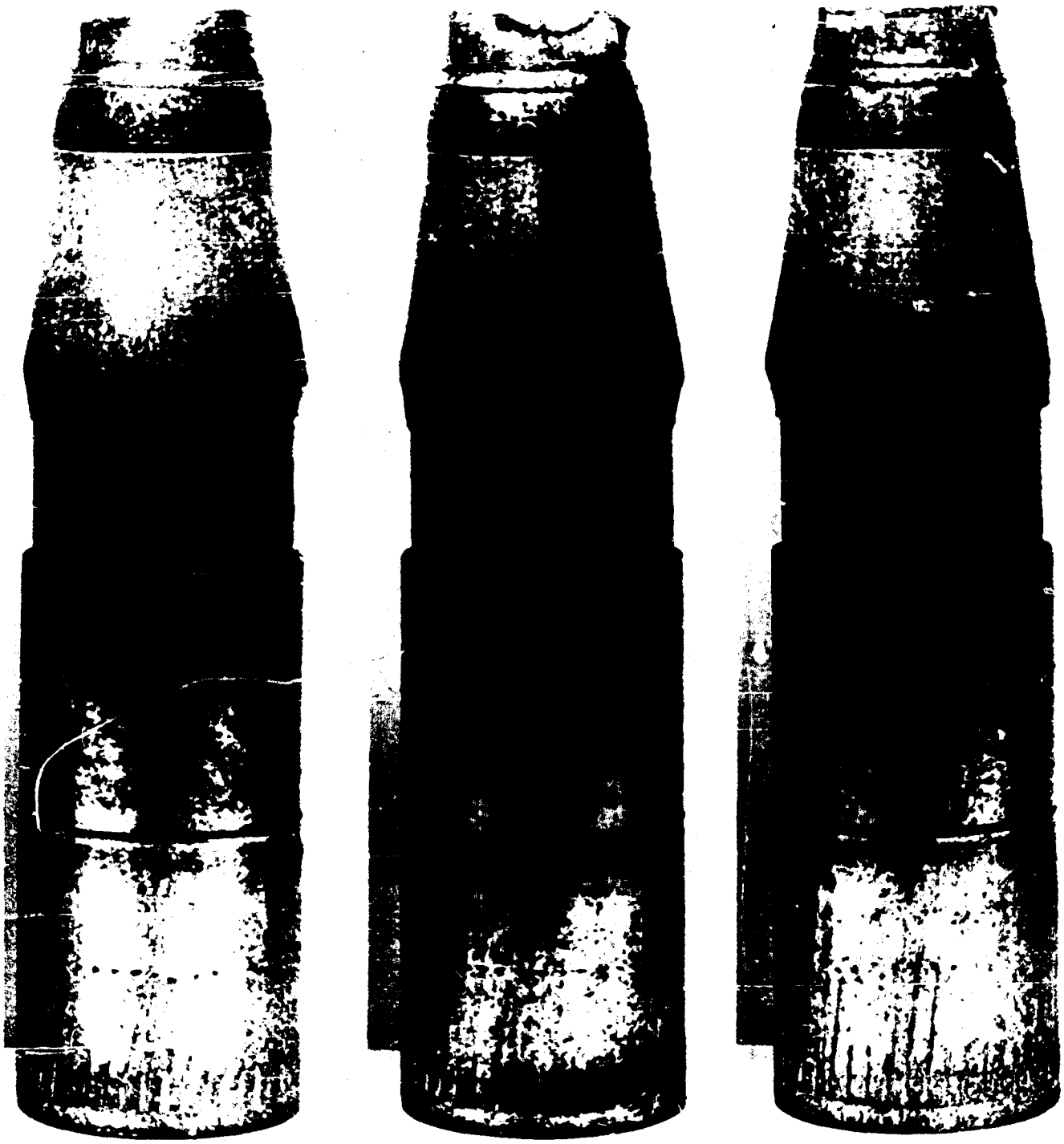
NP9 42201 - Three views (120° apart) of recovered 5"/3"75
Deformable Projectile No. 430. Fired without muzzle squeezer.
1 June 1950 Figure 4 CONFIDENTIAL



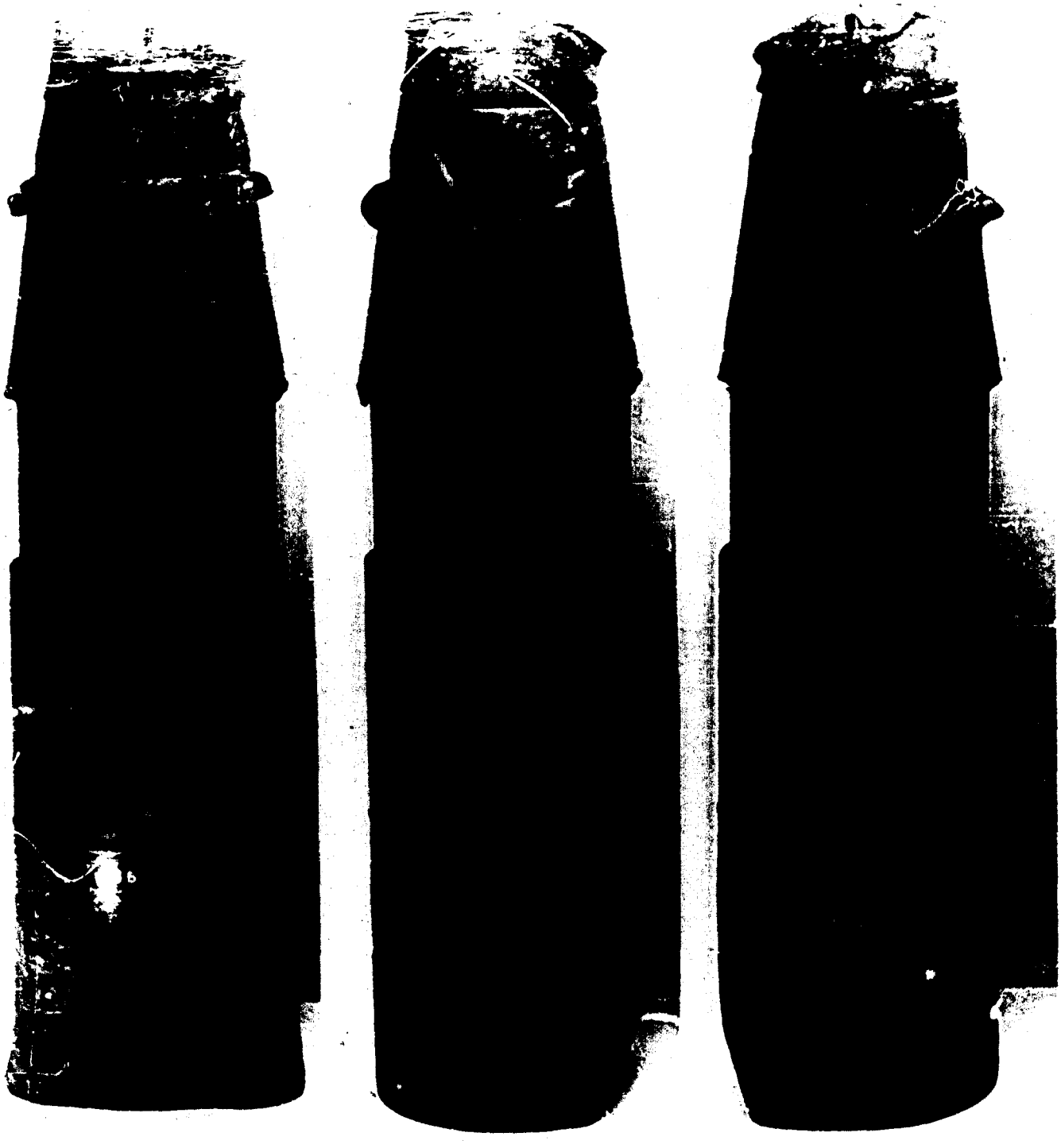
NPG-42202 - View showing part of recovered rear flange from 5"/38.75 Deformable Projectile No. 421 fired with modified squeezer.
22 June 1950 Figure CONFIDENTIAL



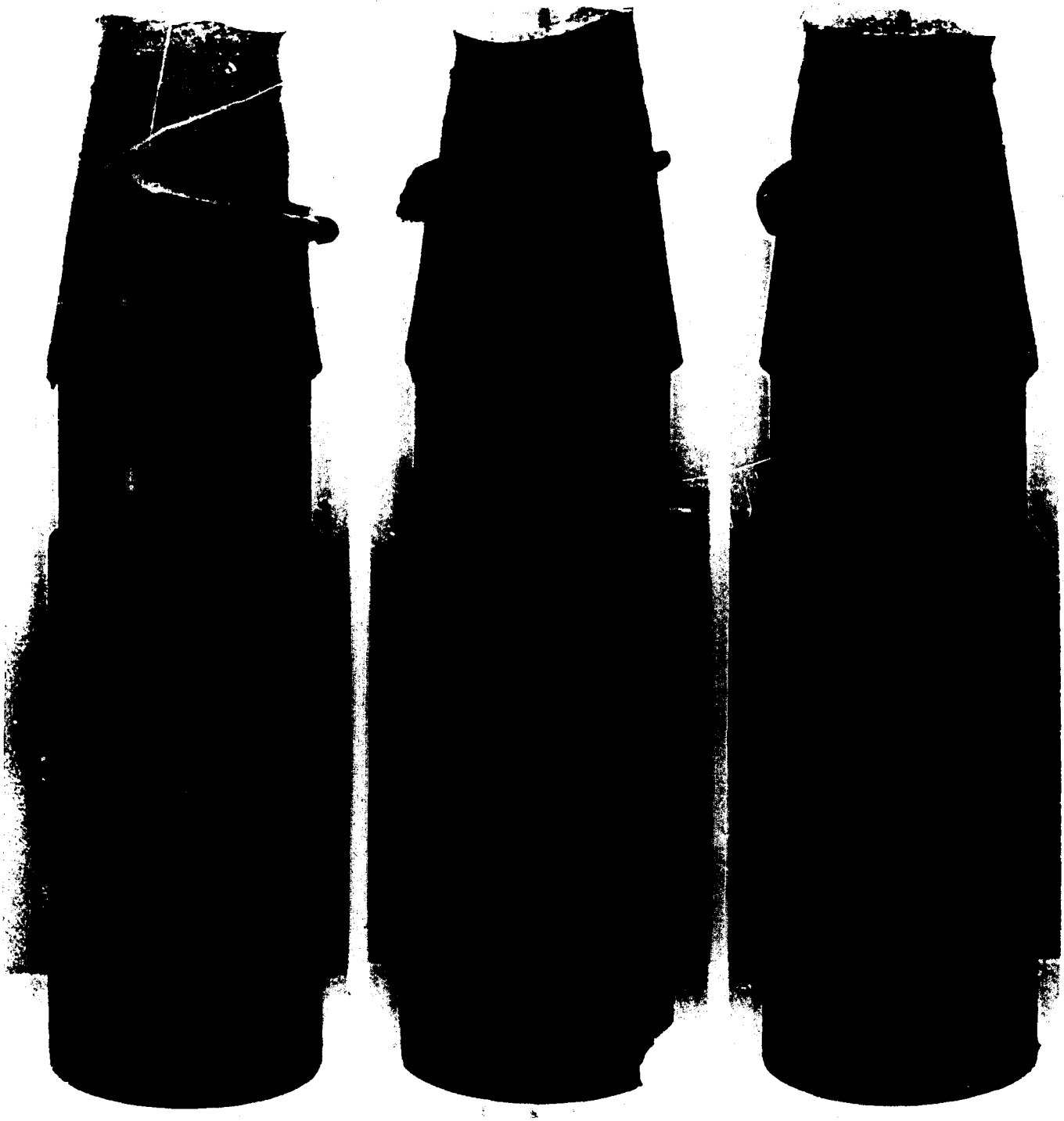
NPS 42826 - Three views (120° apart) of recovered 5"/38 Deformable Projectile No. 432. Fired with modified squeezer.
22 June 1950 Figure 6 CONFIDENTIAL



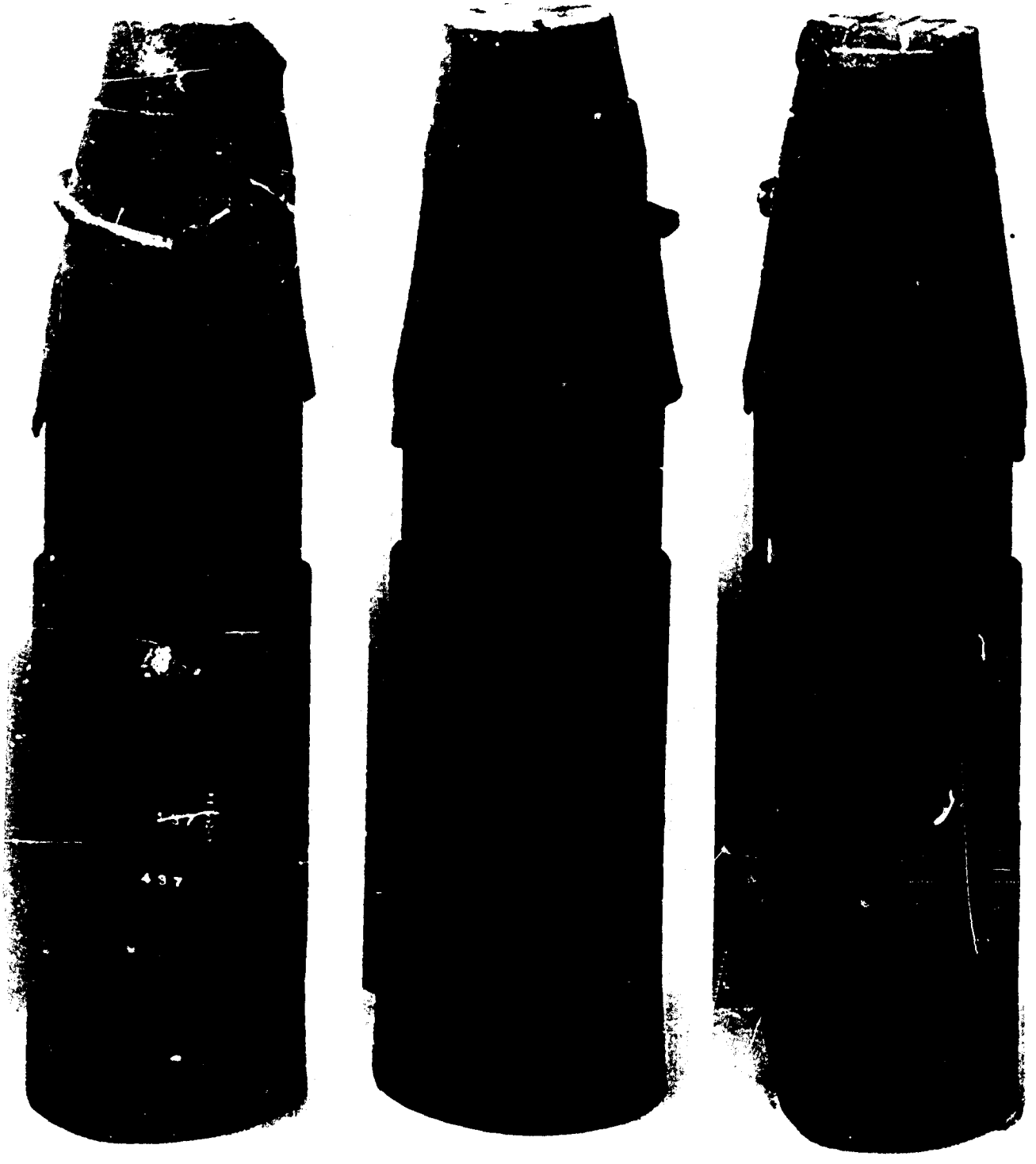
NIW 42827 - Three views (120° apart) of recovered 5"/.38 Deformable Projectile No. 433. Fired with modified squeezer.
22 June 1950 Figure 7 CONFIDENTIAL



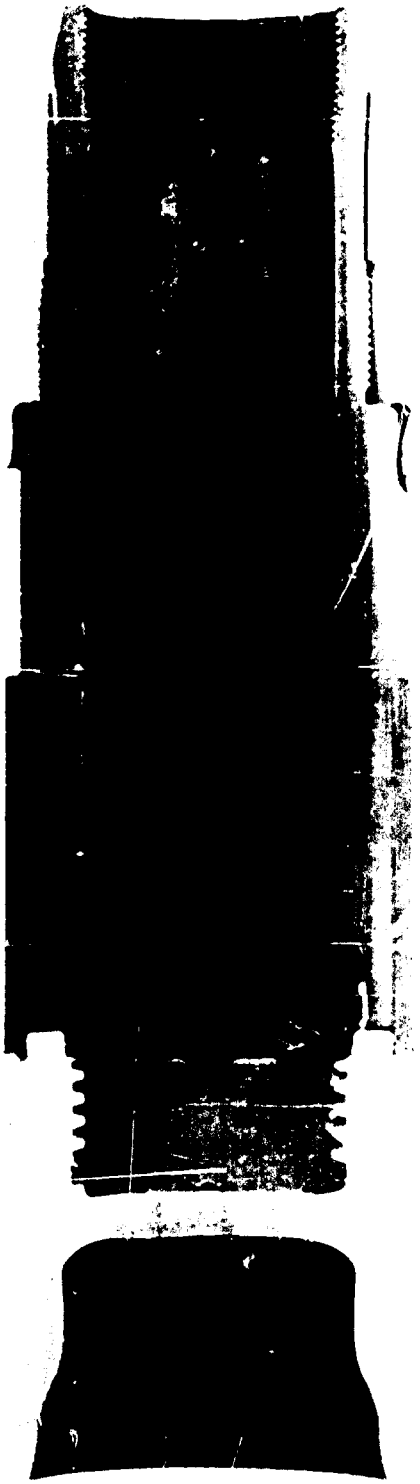
NP9 42828 - Three views (120° apart) of recovered 5"/3".75
Deformable Projectile No. 435. Fired with modified squeezer.
11 August 1950 **Figure 8** CONFIDENTIAL



NPG 42829 - Three views (120° apart) of recovered 5"/3.75
Deformable Projectile No. 436. Fired with modified squeezer.
10 August 1950 Figure 9 CONFIDENTIAL

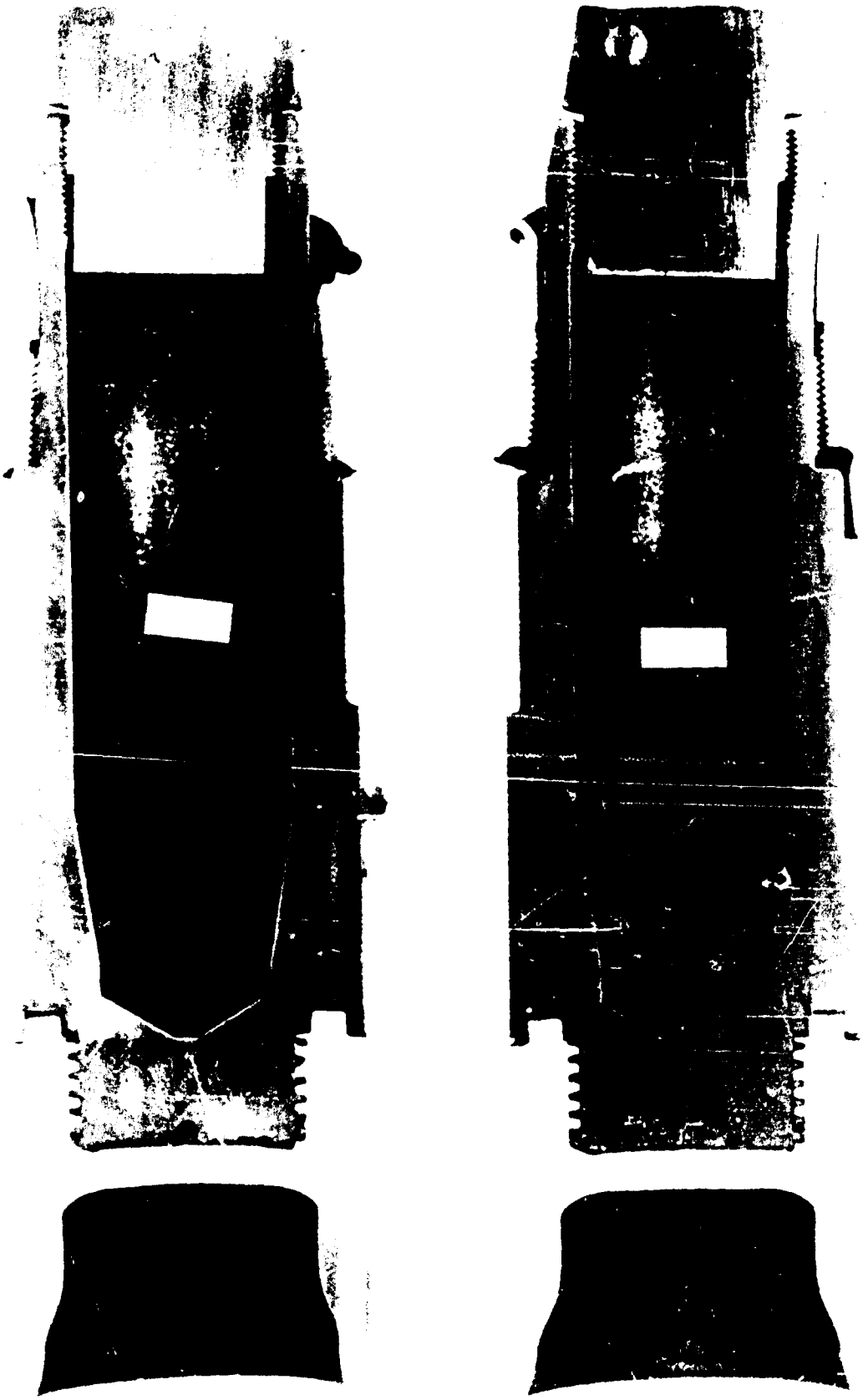


NP9 42830 - Three views (120° apart) of recovered 5"/3"75
Deformable Projectile No. 437. Fired with modified squeezer.
11 August 1950 Figure 10 CONFIDENTIAL



NP9 42831 - View showing section (center line) of recovered 5"/38.75 Deformable Projectile No. 433.
22 June 1950 Figure 11 CONFIDENTIAL

NP9 42832 - View showing section (center line) of recovered 5"/38.75 Deformable Projectiles Nos. 432 and 435.
11 August 1950 Figure 12 CONFIDENTIAL

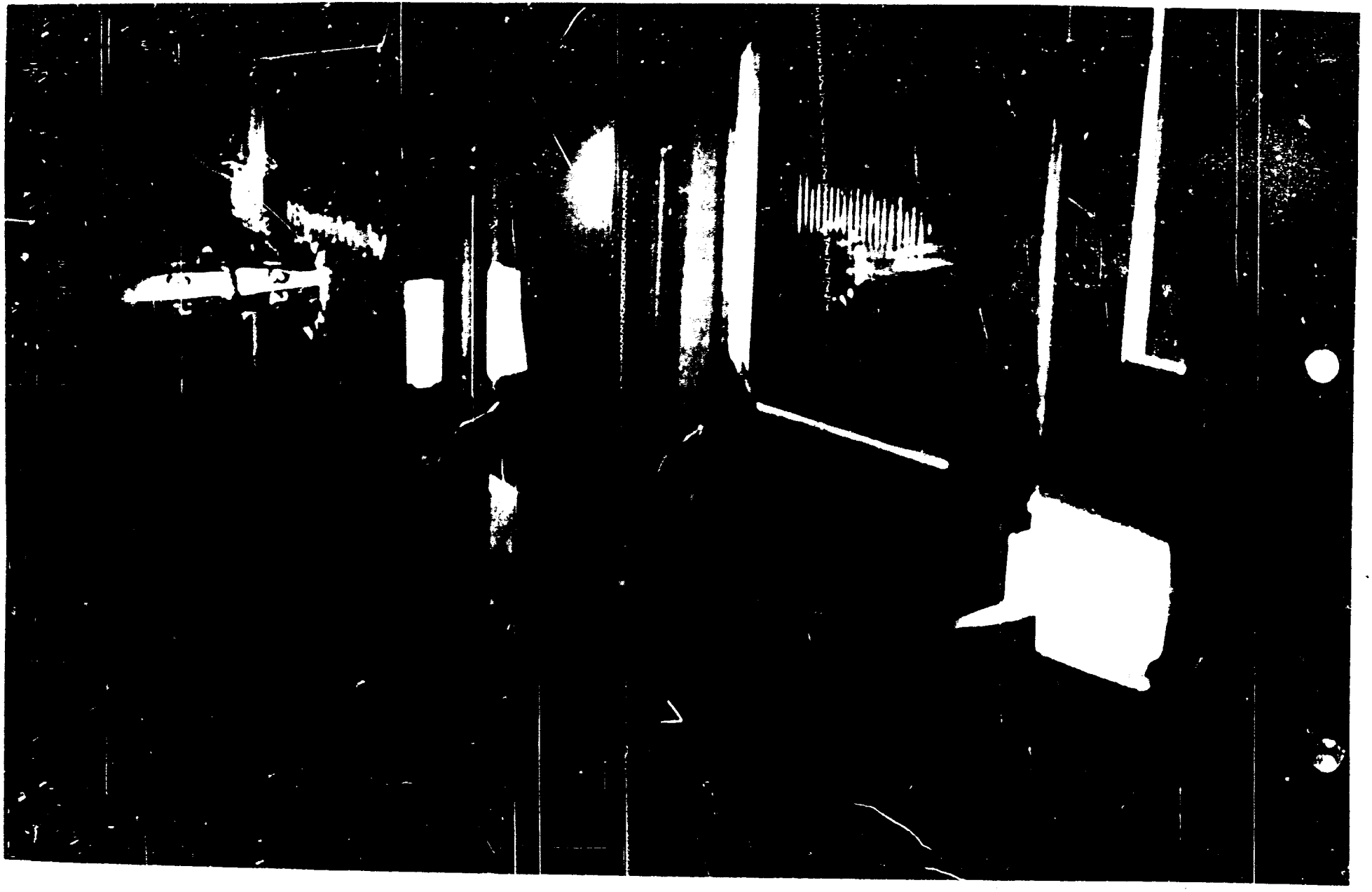


NP9 42949 - View showing section (center line) of recovered 5"/38.75 Deformable Projectiles Nos. 436 and 437.
11 August 1950 Figure 13 CONFIDENTIAL

NP9 [illegible] - Microflash photograph of [illegible] deformable projectile [illegible] in flight. Fired without muzzle squeezer.
1 June 195[illegible]

Figure 14

CONFIDENTIAL



NP-9 42951 - Microflash picture of 5" 3"75 Deformable Projectile No. 329 in flight. Fired without muzzle squeezer.
1 June 1950

Figure 15

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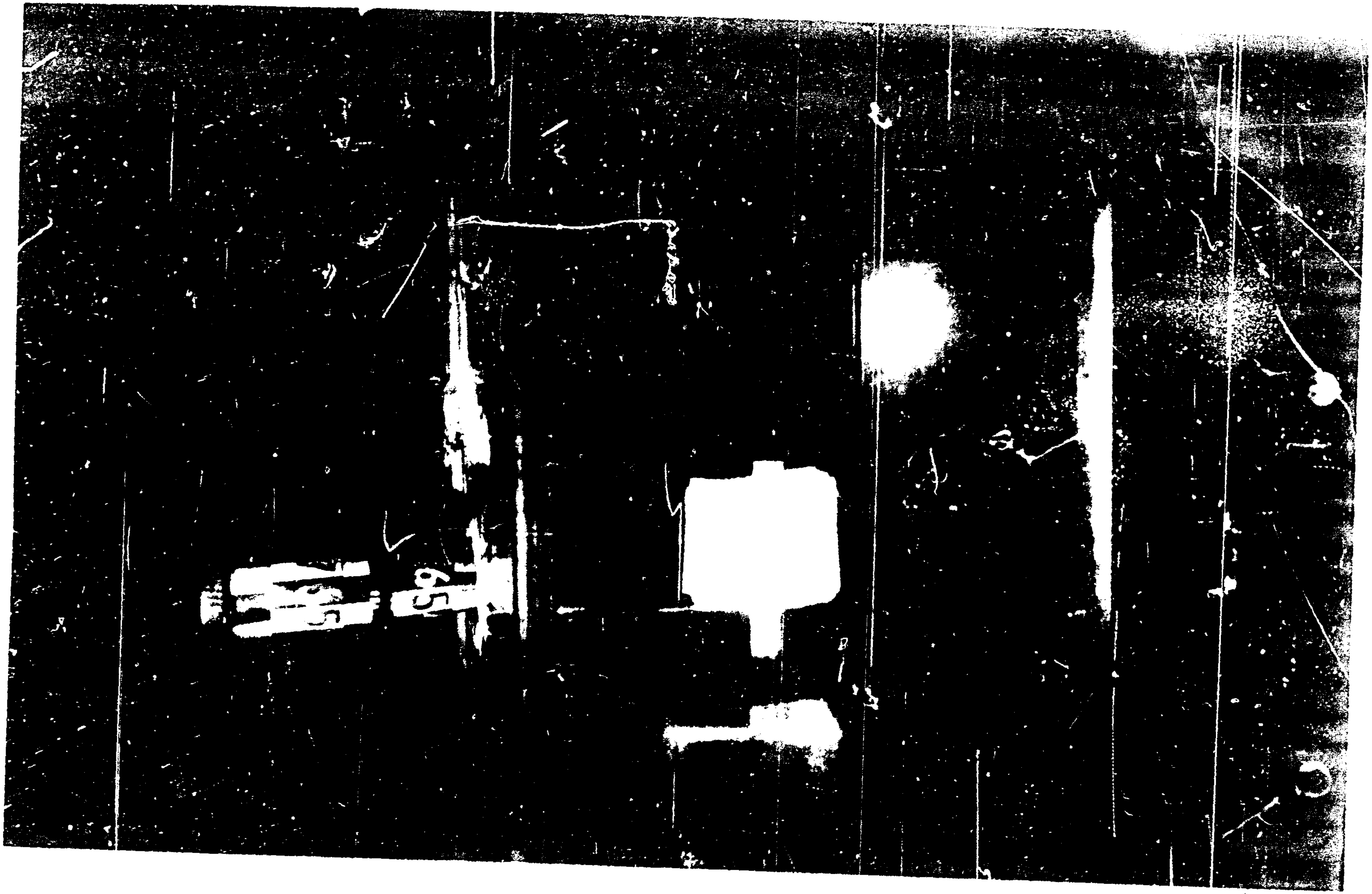

[illegible] 42952 - Microflash picture of [illegible] in flight. Fired without muzzle squeezer.
[illegible] June 195[illegible]

Figure 1[illegible]

NP9 42955 - Microflash picture of 5"/38 Deformable Projectile No. 431 in flight. Fired with muzzle squeezer.
22 June 1950

Figure 17

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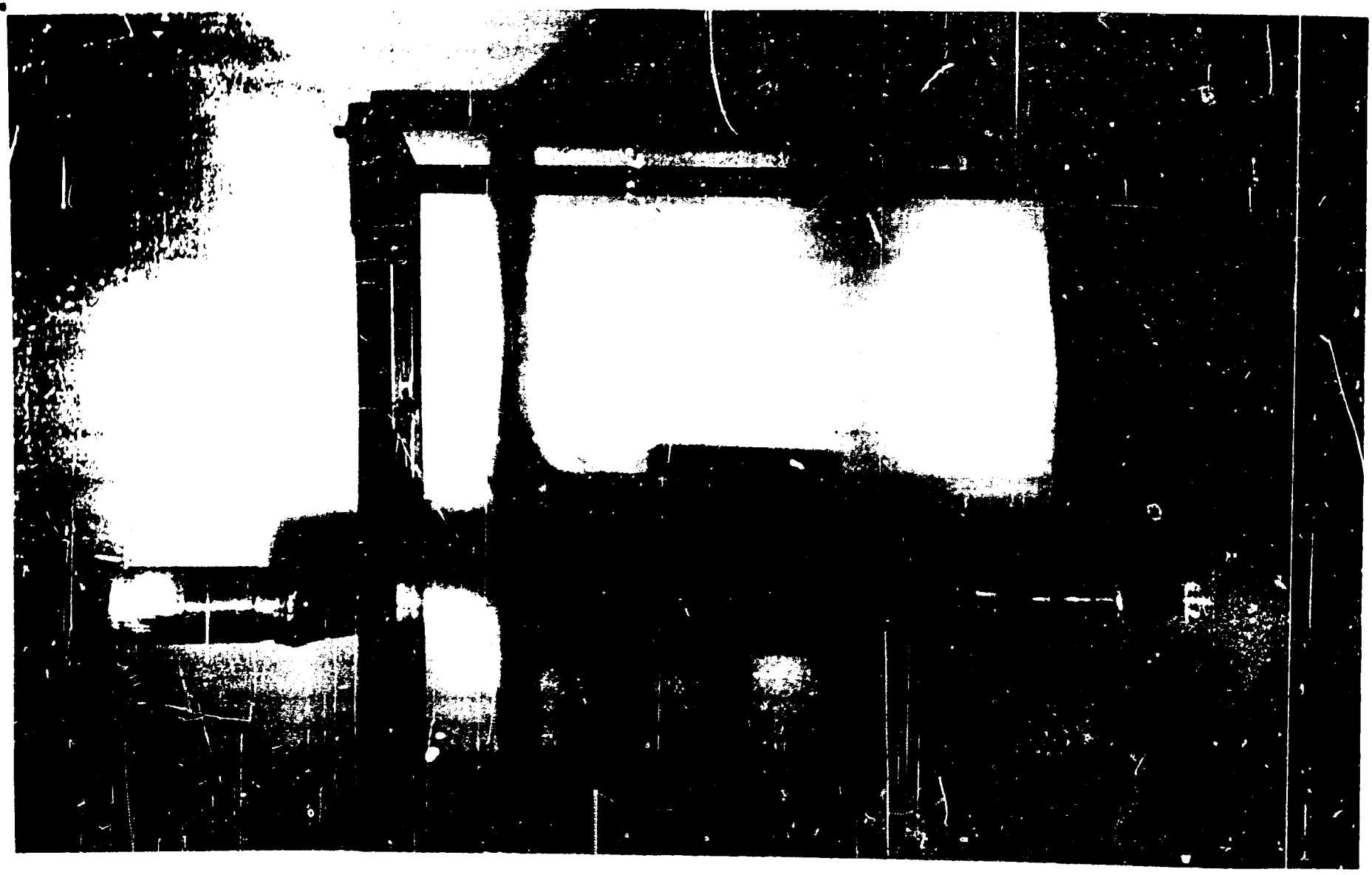
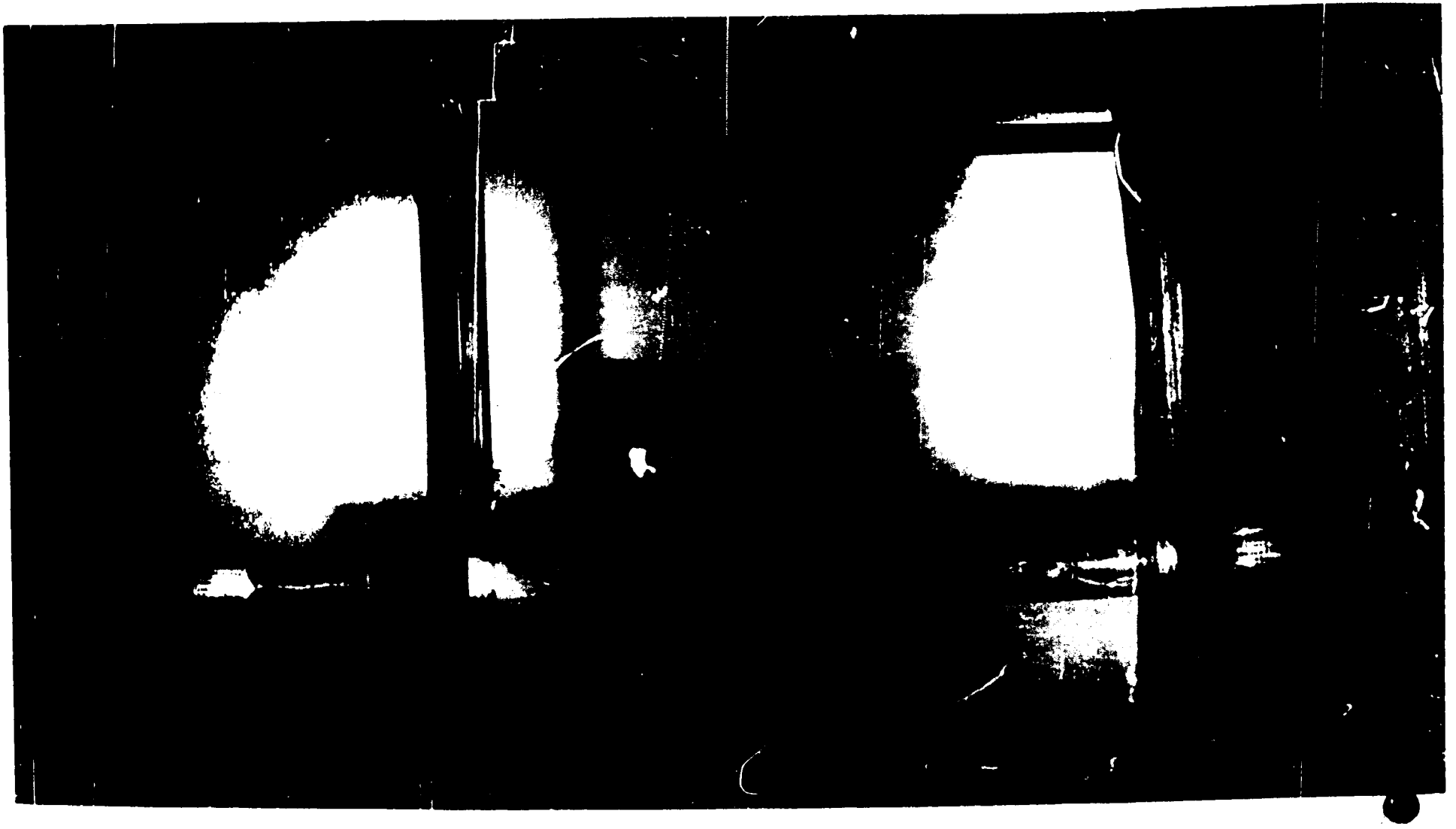


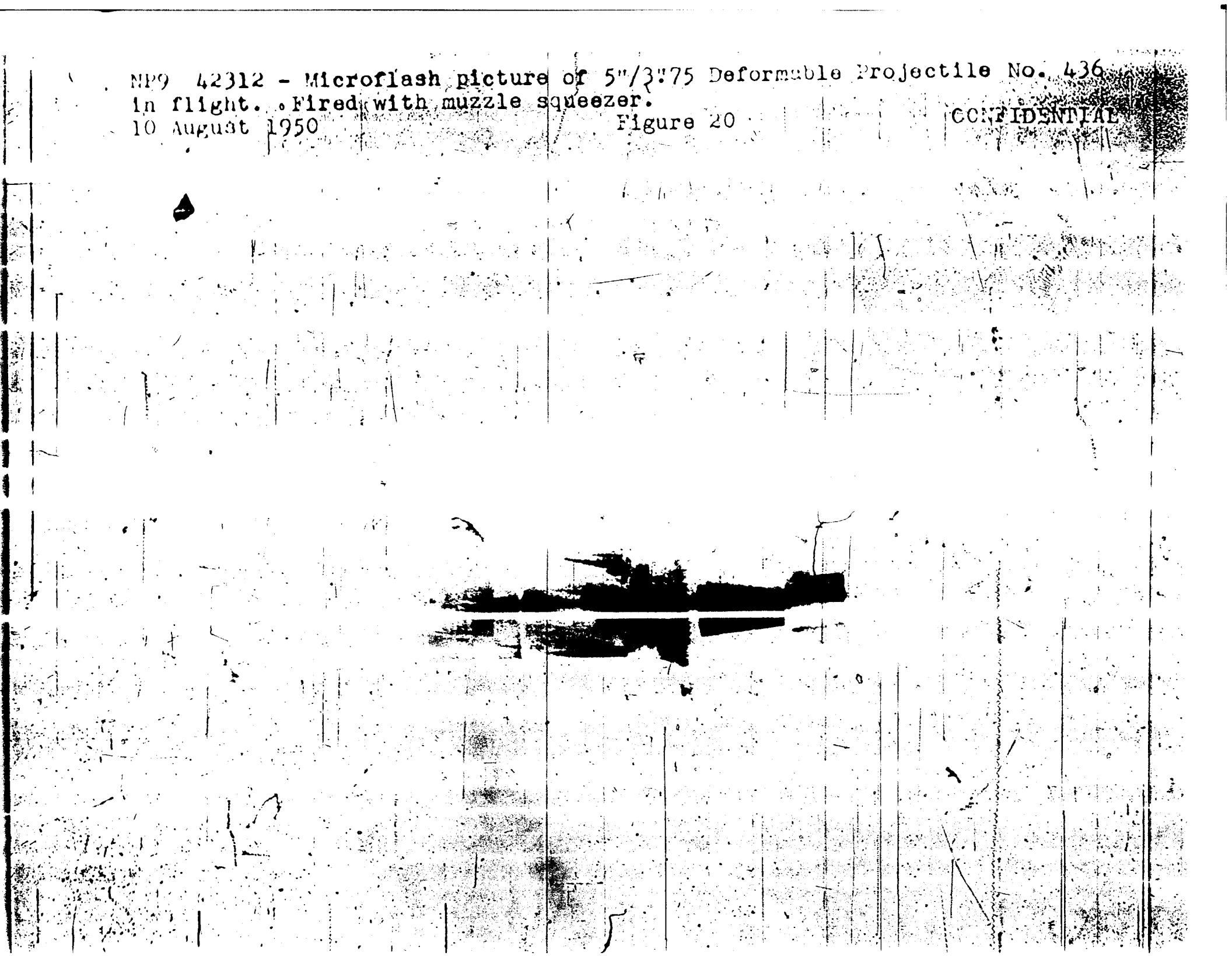
NP9 42954 - Microflash picture of 5"/3.75 Deformable Projectile No. 492 in flight. Fired with muzzle squeezer.
22 June 1950 Figure 18



NP9 42955 - Microflash picture of 5"/3775 Deformable Projectile No. 433 in flight. Fired with muzzle squeezer.
22 June 1950 Figure 19 CONFIDENTIAL

NP9 42312 - Microflash picture of 5"/3.75 Deformable Projectile No. 436 in flight. Fired with muzzle squeezer.
10 August 1950

Figure 20



NP9 42310 - Microflash picture of 5"/38.75 Deformable Projectile No. 434 in flight. Fired with muzzle squeezer.
10 August 1950

Figure 21

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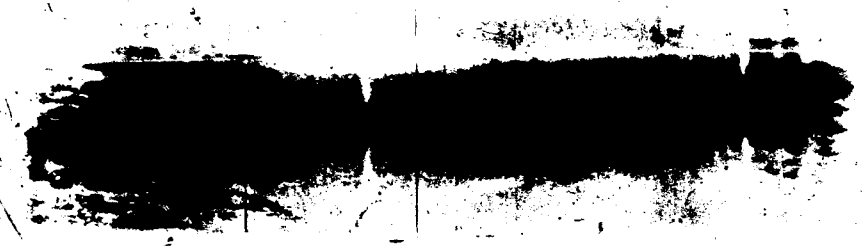


NPG 42517 - Microflash picture of 5"/38.75 Deformable Projectile No. 437 in flight. Fired with muzzle squeezer.
11 August 1950 Figure 22 CONFIDENTIAL

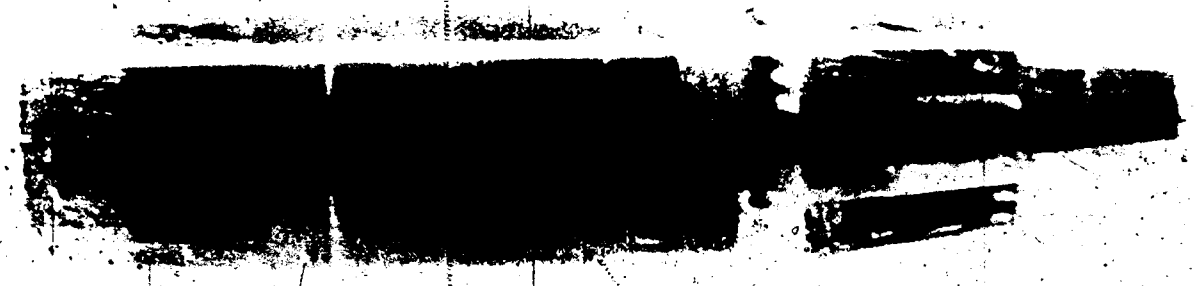
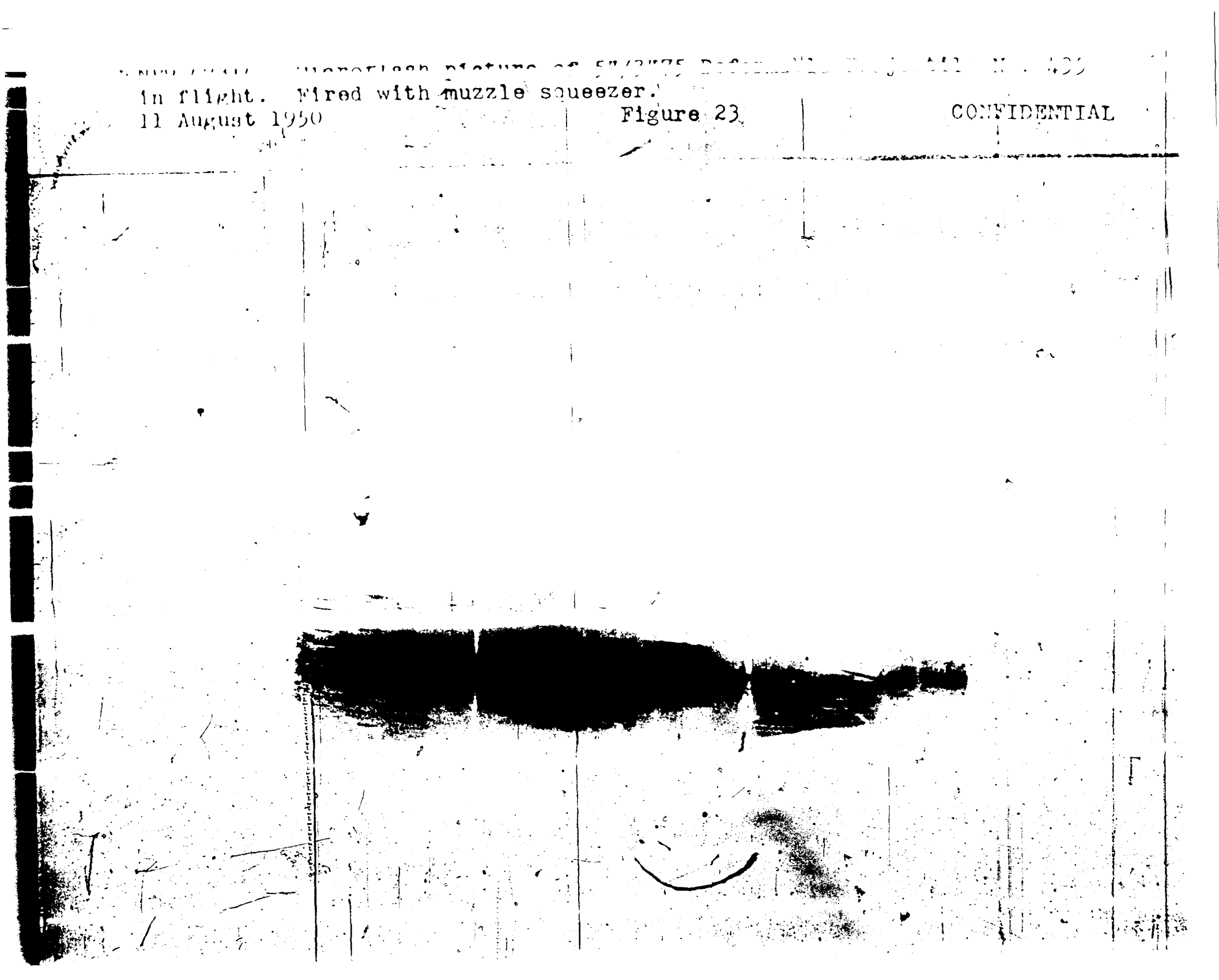
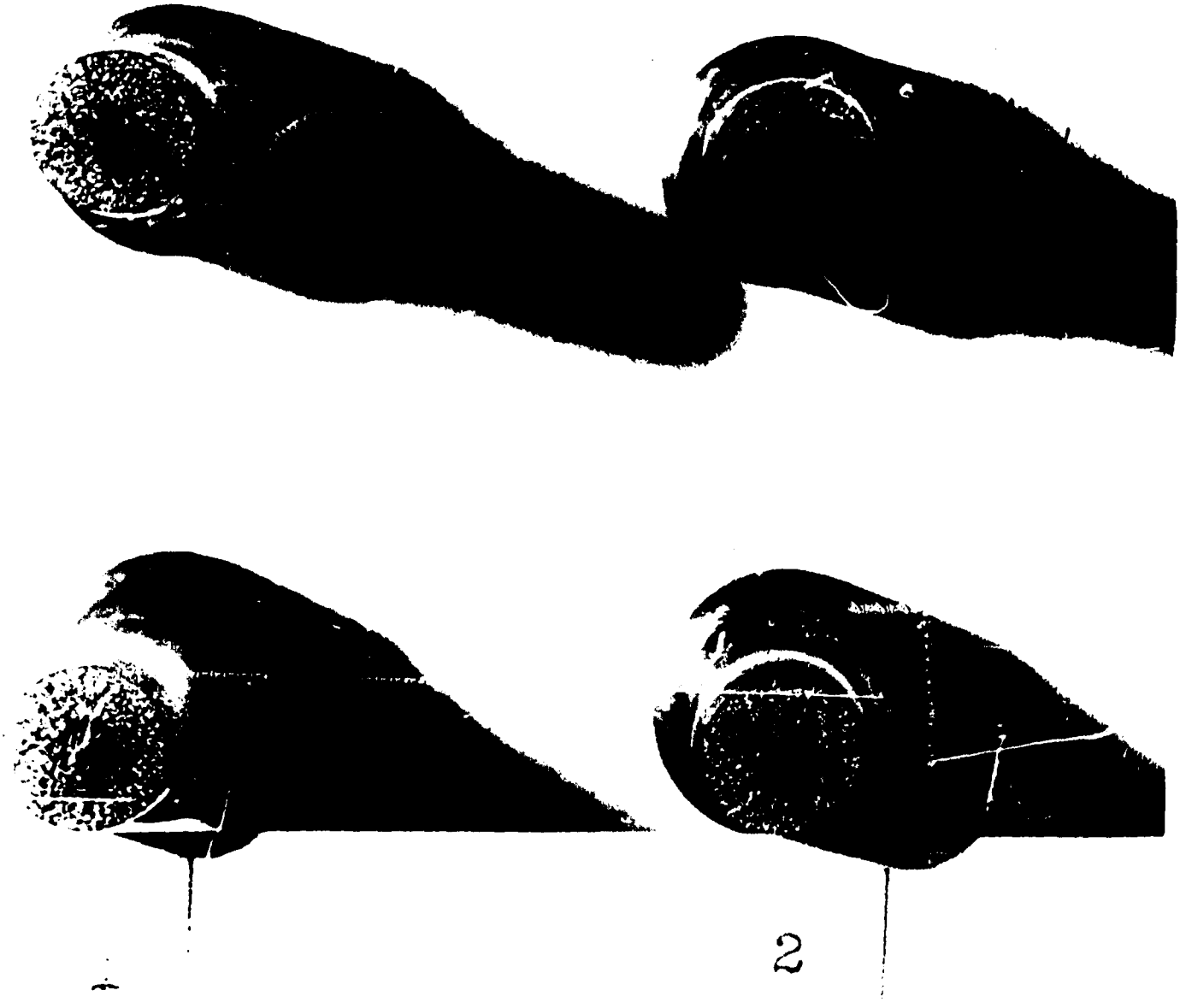


Figure 23

In flight. Fired with muzzle squeezer.
11 August 1950





- Fracture Surfaces of Extensometer AA Steel Tensile
imens.

Figure 44

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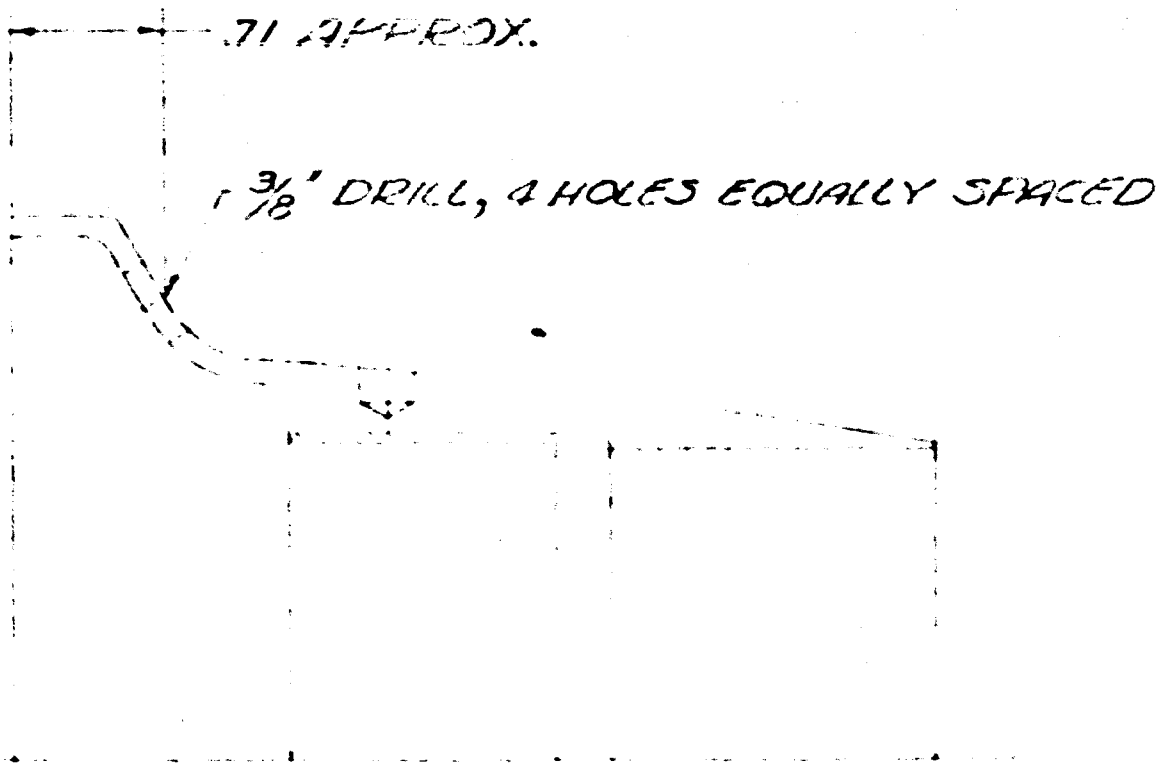
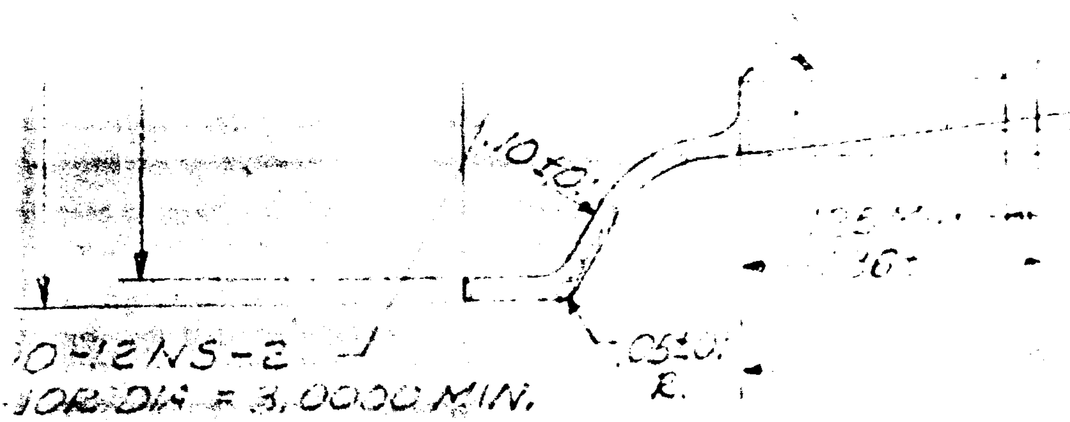

.71 APPROX.
3/8" DRILL, 4 HOLES EQUALLY SPACED



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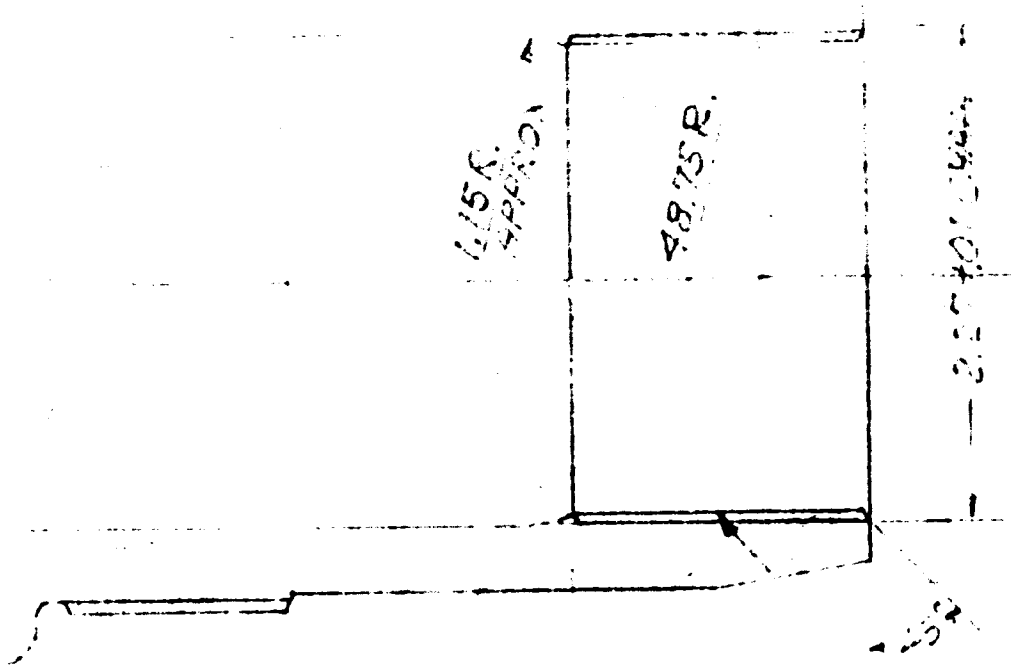
48.75 R.
2595

NP9 42533

5"/3"75 GUN TYPE A MOD.0 NO.14765

Bore Enlargement of Squeeze Attachment No.2
(Heat No.1208-3)
vs
Distance Aft of Muzzle

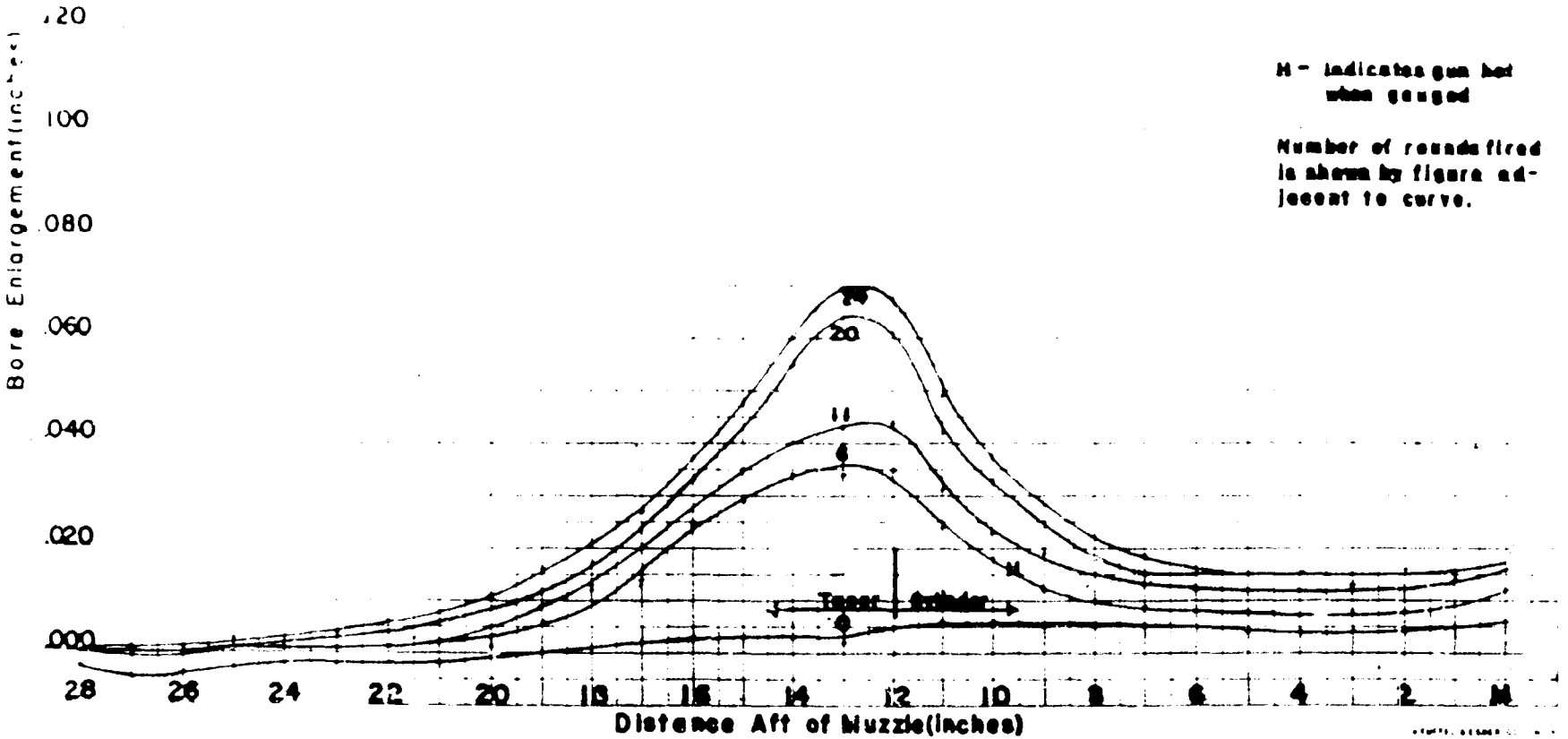

Figure 27

NP9 42533 - Projectiles of this test lie between rounds 15 to 24 inclusive.
3 November 1950

CONFIDENTIAL

FIGURE 2B

Recovery Firing of 5"/3?75 Deformable Projectiles with Forward Skirts

- -

TABLE II

Strain Measurements
on 5"/3?75 Squeeze-Bore Gun No. 14765
22 June 1950

Strain Gage Position (Distance from Muzzle)	Maximum Tangential Strain (Micro-inch per inch)	
	Projectile No. 432	Projectile No. 433
46?5		
32?5	420	475
25?5	510	577
18?5	916	720
11?5	1030	828
6?0	1575	1200

STAR GAUGE DATA

Muzzle

5/13.25   5   1926

3.763	3.776
760	770
758	770
758	771
756	773
757	772
757	772
757	773
761	774
765	773
776	790
788	801
807	823
843	852
870	874
884	889
913	912
923	934
960	954
982	982
4.0?2	4.012
[illegible]	4.016
[illegible]	4.010
[illegible]	.?0
.52	.132
.63	.160
.?1	.?1
[illegible]	.222
2??	253

Note: All readings taken cold before firing

#10 Rev 15 ... [illegible]

Aug. 10 ... [illegible]

[illegible signature]

MUZZLE

5/13/75 A 14765

Mz 1Q	3 762	3 773
1	766	774
2	759	772
3	758	772
4	757	772
5	757	770
6	756	771
7	758	770
8	766	774
9	768	779
10	777	786
11	787	796
12	817	815
13	843	850
14	872	871
15	888	888
16	910	915
	933	933
	966	958
	987	984
	4 017	4 016
	[redacted]	[redacted]
22	070	070
23	088	097
	131	139
	160	159
	191	189
	222	221
28	253	252

Note: Measurements taken after 1st round
[illegible]

Aug 16

[illegible]

0	962	993
0	962	993
0	960	994
0	959	994
0	958	993
0	959	993
0	958	993
0	960	994
0	962	995
0	968	995
0	978	995
0	981	984
0	982	982
0	969	978
0	971	978
0	991	978
0	994	978
0	934	978
0	953	963
0	987	980
0	1019	1013
[redacted]		
0	971	976
0	1011	1008
0	1032	1030
0	1063	1028
0	993	991
0	1023	1022
0	1035	1033
0	1035	1034

0		3 765	3 775
1		762	773
2		766	774
3		759	775
4	0	760	779
5		758	776
6	0	759	774
7	0	761	774
8	0	764	782
9	0	773	787
10	0	786	795
11	0	792	807
12	0	817	826
13	0	850	860
14	0	875	879
15	0	873	894
16	0	912	917
17	0	955	938
18		963	963
19		982	988
20	0	4016	4015
21	0	[illegible]	4046
22	0	4070	4090
23	0	102	099
24	0	133	131
25	0	162	162
26	0	193	172
27	0	22?	223
28	0	255	254
		K	D

Recovery Firing of 5"/3"75 Deformable Projectiles with Forward Skirts

Wire Impression Method of Determining Spin

Two screens are set up 41"5 apart, each screen consisting of a metal frame with wood inserts, holding an array of parallel equidistant vertical copper wires. The spacing of the wires is 1/2" for the first screen and 3/4" for the second. The projectile is fitted with a flat-nosed dummy nose plug or the equivalent, so that after passing through the screens it bears two sets of impressions of the wires. The angle between the two sets of impressions is measured and from this measurement the rifling of the gun, the muzzle velocity, and the velocity at the spin screens, is computed the percentage of nominal spin. It is assumed that over the short distances involved the spin retardation is negligible.

Recovery Firing of 5"/3"75 Deformable Projectiles with Forward Skirts

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Heat Treatment of Rytense AA Steel for 5"/3"75 Squeezebore Projectiles

1. The Rytense AA bar stock from which the projectile bodies were made was treated as follows:

1550°F	4 hours	Oil quench cold
1000°F	4 hours	Water quench cold

2. Following heat treatment both chemical analysis and tensile tests were taken from the quarter point and the results of these tests are listed below:

Chemical Analysis:

C	Mn	P	S	Si
.47	1.60	.020	.11	.10

Physical Properties:

Y.S. (.01% offset*)	Y.S. (.1%)	T.S.	% El.	% R.A.
67,400 psi	70,700 psi	113,800	13.5	25.4
68,400	72,400	115,100	15.5	31.8

3. The fractures shown by the tensile test were considered to be unusual in that the center was fibrous and the outside was crystalline. Figure 24 (Appendix (B)) presents these fractures.

* Approximately equal to proof stress.